

RISK IDENTIFICATION AND ASSESSMENT

Emissions Identification

IGO is committed to identifying emission sources and potential pathways from prescribed activities. To accomplish this, we employ a multi-faceted approach that includes:

- Utilizing assessment information sought from subject matter experts.
- Conducting site inspections (applicable to the project).
- Comparative analysis with similar premises.
- Accessing available monitoring data.

Emission Characteristics

IGO's environmental risk assessments delve into the type, volume, concentration, and duration of emissions, with a focus on:

- Expected operations and infrastructure within the project's context.
- Foreseeable operations, infrastructure, equipment, and potential operational failures that may occasionally lead to elevated emission levels or different emissions (e.g., plant start-up or shutdown for maintenance).

Pathways and Receptors

The risk assessment process placed great emphasis on identifying pathways and receptors, taking into account:

- Site topography and relevant data such as meteorological information.
- Environmental siting factors to gauge the potential impact of emissions on a receptor.
- Exclusion of employees, visitors, or contractors of the license holder, as they are protected under state legislation from exposure risks, with mandated prevention strategies.

Risk Events

The risk assessment categorized and identified risk events as follows:

- The occurrence of an emission.
- The exposure of a receptor to the emission through an identified actual or likely pathway.
- Potential adverse effects on the receptor resulting from exposure to the emission.

Contextual Considerations

The risk assessment has identified foreseeable risk events, taking into account the project's contextual conditions. These risk events encompass activities that may occur outside the realm of normal operational parameters but exclude rare, unforeseeable events, and those stemming from intervening causes.

Public Health Considerations

For risk events with potential impacts on public health, IGO seeks advice from occupational hygienists and specialists in environmental health.

Consequence and Likelihood Assessment

The risk assessment employed risk criteria (Table 1) to assess the consequence and likelihood of risk events. If the determination of consequence and likelihood resulted in a risk rating of high or above, controls were then

applied to reduce the risk rating to at least medium (acceptable, generally subject to regulatory controls), or low (acceptable, generally not controlled).

Table 1: Risk rating matrix (DER, 2017)

	Consequence				
Likelihood	Slight	Minor	Moderate	Major	Severe
Almost Certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Medium	Medium	Medium	High
Rare	Low	Low	Medium	Medium	High

Risk = consequence × likelihood

The following DER (2017) criteria were used to determine the consequence and likelihood of a risk event occurring (Table 9.2 and Table 9.3).

Table 2: Consequence matrix (DER 2017)

	Consequence description	
Consequence	Environment	Health
Severe	On-site impacts: catastrophic Off-site impacts (local scale): high level Off-site impacts (wider scale): mid-level Mid to long term or permanent impact to an area of high conservation value or special significance	Loss of life Adverse health effects: high level or ongoing medical treatment Local scale impacts: permanent loss of amenity
Major	On-site impacts: high level Off-site impacts (local scale): mid-level Off-site impacts (wider scale): low level Short term impact to an area of high conservation value or special significance	Adverse health effects: mid-level or frequent medical treatment Local scale impacts: high level impact to amenity
Moderate	On-site impacts: mid-level Off-site impacts local scale: low-level Off-site impacts wider scale: minimal	Adverse health effects: low level or occasional medical treatment Local scale impacts: mid-level impact to amenity
Minor	On-site impacts: low level Off-site impacts (local scale): minimal Off-site impacts (wider scale): not detectable	Local scale impacts: low level impact to amenity

Consequence description		
Consequence	Environment	Health
Slight	On-site impacts: minimal	Local scale impacts: minimal impacts to amenity

Table 3: Likelihood matrix (DER 2017)

Likelihood	Likelihood description
Almost certain	The risk event is expected to occur in most circumstances
Likely	The risk event will probably occur in most circumstances
Possible	The risk event could occur at some time
Unlikely	The risk event will probably not occur in most circumstances
Rare	The risk event may only occur in exceptional circumstances

Risk Assessment

The risk assessment thoroughly examines potential risks to identified sensitive receptors, focusing on scenarios where the potential for harm is significant. Instances where potential harm is deemed negligible have been deliberately excluded from the risk assessment. A comprehensive review of receptors and their potential impacts, as derived from contextual information, is presented in Table 4.

Table 5 provides a detailed breakdown of potential emissions, their sources, pathways, and receptors associated with the construction, commissioning, and operation of the proposed project. Included within this table is a comprehensive assessment of potential impacts, proposed controls, and the corresponding risk ratings. This systematic presentation allows for a clear understanding of the risk landscape associated with the project.

Table 4: Potential Scenarios

Scenario	Receptor	Impact Severity	Impact Type	Pathway Possibility	Risk Assessment Inclusion
1. Seepage of water via the Tailings Storage Facility (TSF)	Surrounding vegetation	High	Groundwater mounding can disrupt natural aquifer systems, affecting the flow of groundwater and potentially leading to changes in aquifer levels and water quality. This can impact nearby ecosystems that rely on these aquifers.	Yes	Yes
	Yakabindie borefield	High	Groundwater mounding may impact local water supplies, including wells and boreholes used for drinking water or pastoral purposes. It can carry contaminants and pollutants into the groundwater, potentially leading to groundwater contamination. This may include the leaching of harmful chemicals or heavy metals from the tailings. It can lead to decreased water availability and quality, potentially affecting human health and pastoral operations.	No – water migration towards Cosmos open pit sink. Yakabindie aquifer 20km away. No connectivity.	No
	Terrestrial Groundwater Dependent Ecosystem (GDE)	High	The altered groundwater levels and quality can harm ecosystems dependent on groundwater, such as wetlands, riparian zones, and other sensitive habitats. Changes in water availability can negatively affect flora and fauna in the area.	No - evidence of GDEs occurrence has not been documented in the local area.	No
2. Excavation and movement of materials for the construction of the TSF starter embankment and subsequent raises resulting in dust emissions.	Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station)	Low	Dust emissions from excavation and material movement can lead to a deterioration in air quality in the surrounding area. This may result in respiratory problems for workers, nearby residents, especially if fine particles or hazardous materials are present in the dust.	Yes	Yes
	Vegetation and Ecosystems	Low	Dust settling on vegetation and ecosystems can disrupt their health and functioning. It may affect plant growth, damage sensitive habitats, and impact the overall biodiversity of the area.	Yes	Yes

Scenario	Receptor	Impact Severity	Impact Type	Pathway Possibility	Risk Assessment Inclusion
	Tjiwarl Aboriginal Heritage Community	Moderate	Dust emissions can cause annoyance and concern among nearby communities. Addressing community concerns is important for maintaining good relations and social acceptance of the project.	Yes	Yes
3. Flooding of the TSF from a probable maximum precipitation (PMP) event resulting in overtopping, which can lead to dam failure.	Nearby Ecosystems, Drainage Systems (tributaries), Lake Miranda	High	The flooding of the TSF can cause the release of tailings material, which may contain hazardous substances, heavy metals, or other pollutants. This can contaminate nearby water bodies, soil, and ecosystems, leading to long-term environmental damage.	Yes	Yes
	Pastoral Activities	High	If the TSF overflows due to excessive rainfall from a PMP event, it can result in the release of tailings and contaminated water downstream, causing extensive environmental damage, endangering human lives, and impacting pastoral activities.	Yes	Yes
	Tjiwarl Aboriginal Heritage Community	High	Depending on the extent of flooding and downstream population density, there may be risks to human health and safety, including potential evacuation and exposure to contaminated water.	Yes	Yes
4. Surface water runoff from the outer embankments (constructed of tailings and rock armoured) of the TSF resulting in sediment laden run-off.	Nearby Ecosystems, Drainage Systems (tributaries), Lake Miranda	Moderate	The runoff can carry sediments, including fine tailings particles and other contaminants, into nearby ecosystems, such as vegetation, tributaries, and lakes. This sediment discharge can lead to increased turbidity and reduced water and/or quality in these receiving environments.	Yes	Yes
	Tjiwarl Aboriginal Heritage Community, Pastoral Activities.	High	Frequent surface water runoff can lead to erosion of the outer embankments of the TSF. Over time, this erosion can weaken the embankments' structural integrity and potentially lead to embankment failure, releasing tailings into the surrounding area.	Yes	Yes

Scenario	Receptor	Impact Severity	Impact Type	Pathway Possibility	Risk Assessment Inclusion
5. Dust from dried tailings which may include fibrous minerals when winds are 20km/hr or higher.	Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station)	High	Dust emissions can lead to a deterioration of air quality in the vicinity of the tailings facility. This can result in elevated levels of particulate matter (PM) in the air, which may include fibrous minerals. Poor air quality can have adverse effects on human health, causing respiratory problems and exacerbating pre-existing conditions such as asthma and bronchitis.	Yes	Yes
	Surrounding Vegetation, Wildlife	Moderate	Dust deposition on vegetation can hinder photosynthesis and growth, affecting local ecosystems. Additionally, wildlife may be exposed to dust and its potential contaminants, leading to health concerns and habitat disruption.	Yes	Yes
	Tjiwarl Aboriginal Heritage Community	High	Nearby communities to the tailings facility may experience reduced air quality and potential health risks due to dust exposure. This can result in public health concerns, complaints, and negative community perceptions.	Yes	Yes
6. Lateral seepage at the base of the TSF resulting in seepage migration and soil contamination, potentially leading to dam failure.	Surrounding soils and vegetation.	Moderate	Lateral seepage can transport contaminants from the TSF into the surrounding soil. This contamination may include heavy metals, chemicals, or other hazardous substances present in the tailings material. Soil contamination poses risks to ecosystems and vegetation.	Yes	Yes
	Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station) and Local Communities (Tjiwarl Aboriginal Heritage Community)	High	Lateral seepage can create pathways for water to flow through the dam material, potentially leading to piping and erosion. This can weaken the dam's internal structure and contribute to instability. Over time, if lateral seepage and soil contamination continue, they can contribute to a progressive failure process in which small initial weaknesses or failures within the dam lead to larger-scale failures. This can result in the sudden and catastrophic collapse of the dam.	Yes	Yes

Scenario	Receptor	Impact Severity	Impact Type	Pathway Possibility	Risk Assessment Inclusion
7. Failure of tailings slurry or decant return water pipelines during commission testing.	Surrounding soils and vegetation.	Moderate	The spilled slurry or decant water can contaminate the surrounding soil with potentially harmful substances, such as heavy metals, minerals, or chemicals, depending on the composition of the tailings. This can have adverse effects on local ecosystems, including damage to vegetation and disruption of habitats.	Yes	Yes
8. Damage to tailings slurry or decant return water pipelines due to interaction with vehicles or machinery.				Yes	Yes
9. Failure of tailings slurry or decant return water pipelines due to general wear and tear.				Yes	Yes
10. Fauna entrapment within the tailing's impoundment area.	Native fauna.	Moderate	Entrapment of wildlife, including birds, mammals, and reptiles, in the tailings can lead to injury or death of these animals, contributing to a loss of biodiversity in the local ecosystem.	Yes	Yes
11. Utilisation of the tailings decant water by terrestrial fauna resulting in poisoning.	Migratory birds.	High	<p>Tailings decant water may contain hazardous substances or high levels of minerals and metals that are toxic to terrestrial fauna. When animals drink or come into contact with this water, they can suffer from poisoning, which may lead to injury or death.</p> <p>Depending on the species affected and their population size, it may disrupt the natural ecological balance and lead to population declines or extinctions of certain wildlife.</p>	Yes	Yes
12. Excessive amount of water kept within the decant pond resulting in erosion that then leads to failure of the embankment.	Lake Miranda, Tributaries, Native Vegetation, Soils, Wildlife	High	If the embankment fails, it can result in the uncontrolled release of tailings, which may contain harmful substances and pollutants. This can have serious environmental and ecological consequences on downstream terrestrial ecosystems and water bodies (tributaries and lakes). It can lead to habitat destruction, reduced water quality, and harm to flora and fauna.	Yes	Yes

RISK ASSESSMENT

Table 5: Environmental risk assessment – Cosmos Tailings Storage Facility Expansion (TSF3)

Source/Activities	Potential Emissions	Potential Pathway	Potential Receptors	Potential Impacts	Proposed Controls	Consequence	Likelihood	Risk Rating
Seepage of water via the Tailings Storage Facility (TSF)	Tailings seepage	Groundwater mounding	Surrounding vegetation	Groundwater mounding can disrupt natural aquifer systems, affecting the flow of groundwater and potentially leading to changes in aquifer levels and water quality. This can impact nearby ecosystems that rely on these aquifers.	Under drainage recovery system Daily maintenance inspections Geotechnical design Groundwater modelling Vegetation monitoring Water balance calculations Decant return to plant Groundwater quality program (quarterly) in accordance with L7404. Groundwater level monitoring and trigger levels in accordance with L7404. Continue operation of existing active recovery bores and additional bores in accordance with groundwater seepage modelling report (WSP, 2023)	Major	Unlikely	Medium
Excavation and movement of materials for the construction of the TSF starter embankment and subsequent raises resulting in dust emissions	Dust	Disturbance of ground in windy conditions	Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station)	Dust emissions from excavation and material movement can lead to a deterioration in air quality in the surrounding area. This may result in respiratory problems for workers, nearby residents, especially if fine particles or hazardous materials are present in the dust.	Dust suppression Excavating in low wind conditions	Minor	Possible	Medium
			Vegetation and Ecosystems	Dust settling on vegetation and ecosystems can disrupt their health and functioning. It may affect plant growth, damage sensitive habitats, and impact the overall biodiversity of the area.				
			Tjiwarl Aboriginal Heritage Community	Dust emissions can cause annoyance and concern among nearby communities. Addressing community concerns is important for maintaining good relations and social acceptance of the project.				
Flooding of the TSF from a probable maximum precipitation (PMP) event resulting in overtopping, which can lead to dam failure	Tailing slurry or decant water	Spillage into surrounding environment	Nearby Ecosystems, Drainage Systems (tributaries), Lake Miranda	The flooding of the TSF can cause the release of tailings material, which may contain hazardous substances, heavy metals, or other pollutants. This can contaminate nearby water bodies, soil, and ecosystems, leading to long-term environmental damage.	Design for PMP events with suitable freeboard Tailings deposition modelling 48-hour PMP event modelling Dam-break assessment Geotechnical investigations	Major	Rare	Medium

Source/Activities	Potential Emissions	Potential Pathway	Potential Receptors	Potential Impacts	Proposed Controls	Consequence	Likelihood	Risk Rating
			Pastoral Activities and mining/exploration	If the TSF overflows due to excessive rainfall from a PMP event, it can result in the release of tailings and contaminated water downstream, causing extensive environmental damage, endangering human lives, and impacting pastoral activities.	Design compliant with Australian codes and guidelines Piezometers Daily inspections Annual geotechnical audit	Major	Rare	Medium
			Tjiwarl Aboriginal Heritage Community	Depending on the extent of flooding and downstream population density, there may be risks to human health and safety, including potential evacuation and exposure to contaminated water.	Emergency action plan Embankments (6m crest width) and safety bunds	Major	Rare	Medium
Surface water runoff from the outer embankments (constructed of tailings and rock armoured) of the TSF resulting in sediment laden run-off.	Contaminated runoff	Storm event resulting in runoff	Nearby Ecosystems, Drainage Systems (tributaries), Lake Miranda	The runoff can carry sediments, including fine tailings particles and other contaminants, into nearby ecosystems, such as vegetation, tributaries, and lakes. This sediment discharge can lead to increased turbidity and reduced water and/or quality in these receiving environments.	Rock armouring on outer embankments Toe-drains and safety bunds Surface water diversion Surface water management plan Surface water assessments Daily inspections	Moderate	Unlikely	Medium
			Tjiwarl Aboriginal Heritage Community, Pastoral Activities.	Frequent surface water runoff can lead to erosion of the outer embankments of the TSF. Over time, this erosion can weaken the embankments' structural integrity and potentially lead to embankment failure, releasing tailings into the surrounding area.	Annual soil and vegetation monitoring downstream of TSF3	Moderate	Unlikely	Medium
Dust from dried tailings which may include fibrous minerals when winds are 20km/hr or higher.	Tailings dust	Dust liftoff in windy conditions	Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station)	Dust emissions can lead to a deterioration of air quality in the vicinity of the tailings facility. This can result in elevated levels of particulate matter (PM) in the air, which may include fibrous minerals. Poor air quality can have adverse effects on human health, causing respiratory problems and exacerbating pre-existing conditions such as asthma and bronchitis.	Daily inspections. Dust monitoring. TSF operating manual. Tailings will be kept at a slurry density of between 45% to 60% solids. This wet state will minimise dust lift off during operation of TSF3. Rotation of spigot points around the TSF to maintain damp breaches will occur during operations if dust lift off is observed.	Minor	Unlikely	Medium
			Surrounding Vegetation, Wildlife	Dust deposition on vegetation can hinder photosynthesis and growth, affecting local ecosystems. Additionally, wildlife may be exposed to dust and its potential contaminants, leading to health concerns and habitat disruption.		Minor	Unlikely	Medium
			Tjiwarl Aboriginal Heritage Community	Nearby communities to the tailings facility may experience reduced air quality and potential		Minor	Unlikely	Medium

Source/Activities	Potential Emissions	Potential Pathway	Potential Receptors	Potential Impacts	Proposed Controls	Consequence	Likelihood	Risk Rating
				health risks due to dust exposure. This can result in public health concerns, complaints, and negative community perceptions.				
Lateral seepage at the base of the TSF resulting in seepage migration and soil contamination, potentially leading to dam failure.			Surrounding soils and vegetation.	Lateral seepage can transport contaminants from the TSF into the surrounding soil. This contamination may include heavy metals, chemicals, or other hazardous substances present in the tailings material. Soil contamination poses risks to ecosystems and vegetation.	Recovery bores Monitoring bores – weekly Under drainage recovery system Maintenance inspections Geotechnical design Groundwater modelling Vegetation monitoring	Minor	Unlikely	Medium
			Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station) and Local Communities (Tjiwarl Aboriginal Heritage Community)	Lateral seepage can create pathways for water to flow through the dam material, potentially leading to piping and erosion. This can weaken the dam's internal structure and contribute to instability. Over time, if lateral seepage and soil contamination continue, they can contribute to a progressive failure process in which small initial weaknesses or failures within the dam lead to larger-scale failures. This can result in the sudden and catastrophic collapse of the dam.				
Failure of tailings slurry or decant return water pipelines during commission testing.	Tailings slurry	Leakage of tailings slurry	Surrounding soils and vegetation	The spilled slurry or decant water can contaminate the surrounding soil with potentially harmful substances, such as heavy metals, minerals, or chemicals, depending on the composition of the tailings. This can have adverse effects on local ecosystems, including damage to vegetation and disruption of habitats.	Daily monitoring of pipeline Engineering designs and sign-off Leak detection and alarm	Minor	Rare	Low
Damage to tailings slurry or decant return water pipelines due to interaction with vehicles or machinery.					Burial of pipes at road crossings Daily inspections Inductions and training Construction within designated pipeline corridor Survey pickup of pipelines Leak detection and alarm			
Failure of tailings slurry or decant return water pipelines due to general wear and tear					Maintenance schedule Daily inspections Leak detection Flow meters and water balance			
Fauna entrapment within the tailing's impoundment area.	N/A	Fauna entrapped in deposited slurry	Native fauna	Entrapment of wildlife, including birds, mammals, and reptiles, in the tailings can lead	Daily inspections	Slight	Possible	Low

Source/Activities	Potential Emissions	Potential Pathway	Potential Receptors	Potential Impacts	Proposed Controls	Consequence	Likelihood	Risk Rating
				to injury or death of these animals, contributing to a loss of biodiversity in the local ecosystem.				
Utilisation of the tailings decant water by terrestrial fauna resulting in poisoning.	N/A	Fauna utilising decant water	Migratory birds	<p>Tailings decant water may contain hazardous substances or high levels of minerals and metals that are toxic to terrestrial fauna. When animals drink or come into contact with this water, they can suffer from poisoning, which may lead to injury or death.</p> <p>Depending on the species affected and their population size, it may disrupt the natural ecological balance and lead to population declines or extinctions of certain wildlife.</p>	<p>Daily inspections</p> <p>Low-toxicity processing chemicals</p> <p>Hypersaline water not used for drinking (birds and bats will not drink >50K mg/L))</p>	Moderate	Rare	Medium
Excessive amount of water kept within the decant pond resulting in erosion or high phreatic surface that then leads to failure of the embankment.	Slurry spillage	Compromised dam wall integrity	Lake Miranda, Tributaries, Native Vegetation, Soils, Wildlife	If the embankment fails, it can result in the uncontrolled release of tailings, which may contain harmful substances and pollutants. This can have serious environmental and ecological consequences on downstream terrestrial ecosystems and water bodies (tributaries and lakes). It can lead to habitat destruction, reduced water quality, and harm to flora and fauna	<p>Design for PMP events with suitable freeboard</p> <p>Tailings deposition modelling</p> <p>48-hour PMP event modelling</p> <p>Dam-break assessment</p> <p>Geotechnical investigations</p> <p>Design compliant with Australian codes and guidelines</p> <p>Piezometers</p> <p>Daily inspections</p> <p>Annual geotechnical audit</p> <p>Emergency action plan</p> <p>Embankments (6m crest width) and safety bunds</p>	Major	Rare	Medium
Design oversight or operational error	Process water or tailings slurry	Pipeline failure, overtopping, seepage	Surrounding vegetation	The spilled slurry or decant water can contaminate the surrounding soil with potentially harmful substances, such as heavy metals, minerals, or chemicals, depending on the composition of the tailings. This can have adverse effects on local ecosystems, including damage to vegetation and disruption of habitats.	<p>Training</p> <p>Operating manual</p> <p>Annual audits</p> <p>Daily inspections</p> <p>Appropriate procurement of parts</p> <p>24-hour process control</p> <p>Designs based on technical studies</p>	Minor	Unlikely	Medium
Excavation and movement of materials for the construction of the TSF starter embankment and	Noise	Noise waves	Human Populations (Bellevue Camp, Kathleen Valley Camp, and Yakabindie Pastoral Station)	Noise emissions from excavation and material movement can lead to nuisance noise in the surrounding area.	<p>Dust suppression</p> <p>Excavating in low wind conditions</p>	Minor	Possible	Medium

Source/Activities	Potential Emissions	Potential Pathway	Potential Receptors	Potential Impacts	Proposed Controls	Consequence	Likelihood	Risk Rating
subsequent raises resulting in Noise			Tjiwarl Aboriginal Heritage Community	Noise emissions can cause annoyance and concern among nearby communities. Addressing community concerns is important for maintaining good relations and social acceptance of the project.	Distance separation from nearby receptors. TSF3 within existing active mining area.	Slight	Unlikely	Low